RESEARCH ON THE SURGICAL ANATOMY OF THE MIDDLE MENINGEAL ARTERY.[1]

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THE large number of methods given for locating the trephine opening for the exposure of the middle meningeal artery, and the entire absence of any reference to their relative values in our English text-books, led me to institute the researches which furnish the material for this paper. The practical end which I had in view was to determine whether any one of these methods was so far superior to the others as to warrant its selection by preference, and to ascertain the advantages and disadvantages of the various methods.

The meagreness of the descriptions of the middle meningeal artery in our English anatomical treatises in proportion to its surgical importance, the wide variations of these descriptions from each other, and the equally wide variations of the course of the artery in various skulls from the description given in any of the books, led me to precede my investigations as to sites for trephining by research upon the course of the principal branches of the artery.

Some other points of interest have also taken some of my attention.

The investigations made consisted of the examination of the course of the artery on both sides of fifty skulls from the osteological museum of the Northwestern University Medical School, and of thirty operations upon the cadaver, made in the laboratory of operative surgery in the same institution. The skulls used,

[1] Read before the Chicago Medical Society, February 17, 1896.

being those of subjects brought to the college, are from adults, and frequently from those past middle life or even in advanced years. It is necessary to state this because of variations in the artery which take place at various ages.

Course.—My researches on the course of the artery were confined chiefly to its intracranial portion.

In describing the course of the artery I have treated it as it appears on the inner surface of the skull, and it must be borne in mind that the location of the sutures on the inside of the skull does not correspond to that on the outside, owing to the overlapping of the bones composing the sutures. The lower part of the coronal suture, for instance, is from one-half to one centimetre farther back on the inside than the outside, owing to the overlapping of the frontal by the parietal in this location. The squamo-parietal suture, for a like reason, is from one to one and one-half centimetres or more lower on the inside than on the outside of the skull.

The artery is described as lying between the bone and the dura mater, but I have been able to show that a demonstrable layer of the dura, or perhaps I might be more correct in saying, a process from the dura, covers the outer surface of the artery and its branches, so that when the dura is separated from the bone, the artery clings to the former. This adherence to the dura is very firm, so that the artery is separated from it with great difficulty only. I would infer from this close adherence that in cases of extradural hæmorrhage the artery would be found beneath the clot in all cases, never adhering to the bone unless held in contact with the latter by running in a canal.

Presence of a Main Trunk within the Cranium.—I found that in 95 out of the 100 arteries examined there was present within the cranium what I have denominated the main trunk, which divided at a greater or lesser distance from the foramen spinosum into two branches, an anterior and a posterior.

In one skull only did the artery divide on both sides at the foramen spinosum, while in one it divided at this location on the right side, and in another upon the left side. In one skull the artery on the left side entered as two separate branches, the

anterior and posterior, through two foramina spinosa of equal size, one situated just in front of the other.

Point of Division of the Main Trunk.—The point of division of the main trunk into the anterior and posterior branches is at a distance of from 0.2 to 5.5 centimetres from the foramen spinosum, measured in a direct line, being under one centimetre sixteen times, between one and three centimetres sixty times, and over three centimetres nineteen times.

The point of division is located on the temporal bone in fifty-eight cases, on the sphenoid in twenty-one, on the squamosphenoidal suture in fifteen, and on the spheno-parietal suture once.

In the course of my article I shall have occasion to refer to the exhaustive article of Steiner on the same subject, published in 1894.[1] He found in 100 skulls that the point of division occurred in 57 per cent. at the foramen spinosum, a main trunk being present in only 43 per cent. of cases.

Length of the Main Trunk.—The length of the main trunk corresponds with the distance from the foramen spinosum to the point of division, being practically identical if this distance is not above two centimetres, but being from 0.1 to 1.2 centimetres greater when this distance is above two centimetres, the difference being due to the curved course of the artery.

Steiner gives the length of the main trunk in the forty-three cases in which a main trunk was present as from one to 3.5 centimetres in forty-three (*sic*) cases, and from 3.5 to five centimetres in eight.

Direction of Main Trunk.—The main trunk upon leaving the foramen spinosum passes in nearly every case at first outward, either directly or inclined somewhat backward or forward. Unless the trunk is a short one it changes its direction, after running a distance of from 0.2 to 1.7 centimetres, to forward and outward. In those cases where its primary direction was outward and forward, it turns more forward. When the trunk is very long, its terminal portion is directed either upward or upward and backward.

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[1] Zur chirurgischen Anatomie der Arteria meningea media, Archiv für klinische Chirurgie, Band XLVIII, 1, 101.

Curves of Main Trunk.—Nearly every main trunk, unless very short, has at least a gentle curve; trunks of moderate length inclining more forward at their terminations than at their beginning. In some cases the curves are much more decided, approximating a right angle in eleven cases, and being but little greater than a right angle in six more. As seen above, long main trunks may have a second curve.

Location of the Main Trunk.—From the foramen spinosum the main trunk passes on to the temporal bone, either immediately, as in the great majority of cases, or after a short course upon the sphenoid bone or squamo-sphenoidal suture. Upon the temporal bone it is usually between one-half and one centimetre from the squamo-sphenoidal suture. From the temporal, if the trunk is long, it passes, almost invariably, onto the great wing of the sphenoid, occasionally lying upon the squamo-sphenoidal suture for a short distance first.

Anterior Branch.—The anterior branch is generally larger than the posterior and in a considerable percentage of cases appears to be a continuation of the main trunk.

Direction and Location of the Anterior Branch.—In the ninety-five cases in which a main trunk is present, the point of division occurs on the squamous portion of the temporal in fifty-eight. In these, of course, the first portion of the anterior branch lies on this bone. These, with rare exceptions, cross the squamo-sphenoidal suture, and from this on, take a course similar to that of those beginning on the squamo-sphenoidal suture or great wing of the sphenoid,—namely, forward and upward across the upper part of the great wing.

The prevailing primary direction of the anterior branch on the great wing of the sphenoid is, as has been mentioned, forward and upward. Whatever its primary direction, it almost invariably describes a curve on the upper part of the great wing, so as to become directed more backward. This curve varies from a very gentle one to one approximating a right angle, as occurred in twelve cases, intermediate grades varying between these two extremes.

From the upper portion of the great wing of the sphenoid

the anterior branch passes across the spheno-parietal suture onto the parietal bone. The point of crossing is anterior to the middle of the suture in more than 75 per cent. of cases, being immediately back of its anterior extremity,—that is, immediately posterior to the coronal suture, in 40 per cent. In the four cases where the anterior branch does not cross the upper part of the sphenoid it, at least, lies upon the spheno-parietal suture. It will thus be seen that, for practical purposes, it may be said that in every case the anterior branch crosses the spheno-parietal suture, the point of crossing being at either extremity or at any intermediate point, but generally on the anterior half. As the length of the suture is from one to 1.5 centimetres, the greatest distance from the lower extremity of the coronal suture at which the anterior branch may cross it is 1.5 centimetres.

The distance of the anterior branch behind the external angular process of the frontal bone varies from 1.7 to 3.7 centimetres, being between two and three centimetres in most cases. It is measured on a line drawn horizontally backward from the extremity of the process, which reaches the artery on the upper part of the great wing of the sphenoid. In a few cases where the main trunk is long, it is reached instead of the anterior branch.

On the parietal bone the anterior branch takes a direction upward, or, more frequently, upward and backward, approximately parallel with the coronal suture.

In forty-four cases the anterior branch does not divide. In these cases its course may be said to fall under one of the following four heads : (1) Parallel with the coronal suture and lying practically the same distance behind it as far as its termination at the sagittal suture. This distance may vary from 0.2 to three centimetres, generally being less than one. Under this head are twenty-three cases. (2) Parallel with the coronal suture at first, being within a distance of 1.1 centimetres from it, and then diverging so as to be from two to three centimetres posterior to it at the sagittal suture. Under this head are ten cases. (3) With a long curve convex posteriorly at first near to the coronal suture, then diverging to a distance of between one and two centimetres

and approaching close to the coronal suture at its junction with the sagittal. Under this head are six cases. (4) At first parallel with coronal suture, and one to two centimetres from it, then approaching quite closely to it and again diverging to a distance from 1.2 to two centimetres at its upper extremity.

The description under the first head corresponds closely to that in Morris's " Human Anatomy."

That under the second approximates that of Steiner.

In fifty-six cases the anterior branch divides, twenty-five times on the right and thirty-one times on the left side. In forty-nine cases it divides into two branches, in five into three branches, and in two into four branches. Four times the division takes place in a bony canal.

As to the location of the point of division of the anterior branch, it occurs twice on the sphenoid, three times on the spheno-parietal suture, and in the remaining fifty-one cases on the parietal.

When the anterior branch divides, the description of the courses of its divisions may mostly be included under these heads: (1) Where one division passes upward (and perhaps slightly backward) parallel to the coronal suture and generally within 1.5 centimetres of it, and the other passes obliquely upward and backward. This occurs in thirty-one cases, which is a majority of all the cases where the anterior branch divides, and corresponds rather closely to Krönlein's[1] description of what he considered an average case, which follows: " The anterior branch divides into two principal branches (Hauptzweige), of which the one runs in front of the sulcus of Rolando, the other behind it." I did not study the locations of the two divisions in relation to the sulcus of Rolando, but know that in many cases they would conform to Krönlein's description.

(2) Where both divisions pass upward parallel with each other and with the coronal suture. This occurs in seven cases.

(3) Where both divisions diverge from the coronal suture, passing obliquely upward and backward, so that the anterior

[1] Deutsche Zeitschrift für Chirurgie, 1886, Band XXIII, S. 209–222.

division is from 1.8 to three centimetres, posterior to the coronal suture at its upper extremity. This occurs in seven cases. In the other eleven cases the variations are so great as to prevent classification. One thing noticed in common with them is that in all one of the divisions runs parallel with the coronal suture and within 1.5 centimetres of it through a considerable portion of its course. It will thus be seen that in a great majority of all cases the anterior branch or one of its divisions lies parallel to and within two centimetres of the coronal suture.

Branches of the Anterior Branch.—A branch which is generally found, although small, is the ramus fronto-basilaris. Most frequently its origin is just above the exit of the anterior branch from the bony canal when the latter is present, although it sometimes arises inside the canal, escaping from it by a special orifice or small canal. The ramus fronto-basilaris takes a course in a downward and forward direction, frequently running upon the interior surface of the bony ridge lying along the lower part of the coronal suture. It terminates upon the upper surface of the horizontal plate of the frontal bone. This branch may arise low down and perforate the orbital plate from below to reach its destination.

One or more posterior branches are often given off from the anterior branch prior to its division, when the latter occurs, or in a corresponding location where there is no division. The first of these generally is located entirely upon the parietal bone, being directed either horizontally backward or obliquely upward and backward and lying between one and three centimetres above the spheno-parietal and squamo-parietal suture. Its first portion may, exceptionally, be upon the sphenoid or temporal bone.

The second posterior branch, occurring with a little more than one-third the frequency of the first, lies within 1.5 centimetres above the former. It is very seldom that a branch from the anterior branch reaches the occipital bone, instead of being the rule, as Gray's description would lead one to expect.

Posterior Branch.—The posterior branch is generally smaller than the anterior, sometimes being so small that the main trunk

can scarcely be said to divide into an anterior and posterior branch, but rather to give off the posterior branch and continue as the anterior branch. On the other hand, the posterior branch sometimes (in eight cases) appears, from its direction, as the continuation of the main trunk, at the same time being in rare cases larger than the anterior branch. In other cases again, the posterior branch, while not having the direction of the continuation of the main trunk, is larger than the anterior branch. This I noted seven times.

It is sometimes difficult to establish the identity of the posterior branch; for the main trunk occasionally gives off near its origin a small posterior branch which runs along the squamopetrosal junction, and passes a short distance on to the parietal bone. When this branch is small, it corresponds to the external petrosal branch of Steiner, which is from the main trunk ; but when, as occurs in some cases, it is of comparatively large size, its distribution is similar to that of the posterior branch in an average case, and the question arises as to whether this does not more closely approximate the description of the posterior terminal branch of the main trunk than the next one given off.

Again, confusion may arise, when the first posterior branch given off from the main trunk is small, as to whether this, or what, if this be considered the true posterior branch of the main trunk, would be the first posterior branch of the anterior branch, be more justly entitled to be considered the posterior terminal branch of the main trunk; for these two branches—namely, the posterior terminal branch of the main trunk and the first posterior branch of the anterior branch—are found to have a complementary relation to each other in size and location, the one being small when the other is large, and the branch of the anterior branch being located low when the posterior branch is low or small, and high when the posterior branch is high or large.

In deciding in these cases which one I should designate in my description as the posterior branch, I have chosen the one which in size, location, and distribution resembled most closely

the posterior branch in an average case. In cases where the choice has not fallen upon the first branch, running posteriorly from the main trunk, this branch is described as an accessory posterior branch.

Direction and Location of the Posterior Branch.—The posterior branch takes a direction, in the majority of cases, outward and backward or upward and backward. In a much smaller number of cases it passes directly backward horizontally. Whatever its primary direction, it almost invariably becomes inclined more backward as it progresses, so that, as we follow the course of the vessel, we soon find that in a majority of cases it now becomes directed horizontally backward, in a lesser number upward and backward, and in a few upward. Its final direction when it does not divide into terminal branches is horizontally backward in most cases, though it may sometimes be directed obliquely upward and backward and, exceptionally, downward and backward, in this latter case running on to the occipital bone.

The first part of the posterior branch is located in most cases (seventy-three) upon the temporal bone, but not infrequently upon the sphenoid.

Two general descriptions of the course of the posterior branch will apply to most cases. First, in eighteen cases the artery runs outward and backward along the squamo-petrosal junction or upon the squamous portion of the temporal bone, parallel to the squamo-petrosal junction and usually within one centimetre of it. In these cases the posterior branch generally turns backward above the base of the petrous portion of the temporal bone, crosses the squamo-parietal suture close to its posterior extremity and runs backward on the parietal bone above and parallel to the masto-parietal suture. Second,—and this applies to the majority of the cases,—the posterior branch takes a course approximately parallel to the squamo-parietal suture, or, if it begins low down, parallel at first with the squamo-sphenoidal suture, describing a curve, convex upward and forward, which is generally gentle, but occasionally rather sharp. It lies generally upon the squamous portion of the temporal

bone, and within one centimetre of the squamo-parietal suture
in the majority of cases, never being more than two centime-
tres from it, gradually approaching it, and, unless it divides into
its terminal branches on the temporal bone, crossing it gener-
ally within two centimetres of its posterior extremity, and pass-
ing on to the parietal bone, small branches of it reaching the occip-
ital bone. The posterior branch may, though rarely, pass on to
the parietal bone at any part of the squamo-parietal suture.

In fifty-four cases the posterior branch bifurcates into ter-
minal divisions, usually two in number. The point of division
occurs on the temporal bone twenty-five times, on the parietal
bone twenty-four times, and on the squamo-parietal suture three
times. Of the two divisions the inferior is in a great majority
of cases horizontal, while the superior is generally directed
obliquely upward and backward.

On the parietal bone the posterior branch generally gives
off ascending branches, passing either vertically upward or
obliquely upward and backward. In several cases two or three
vertical branches are given off from a highly placed posterior
branch which is directed horizontally backward.

Accessory Posterior Branches.—Accessory posterior branches
were found twelve times. Nine of these run upon or near the
squamo-petrosal junction, barely reaching the posterior inferior
angle of the parietal bone. Three of them cross the squamous
portion higher up, but one of them passing off this onto the
parietal.

Curves of the Middle Meningeal Artery and its Branches.—
I wish here to call attention to the great number of curves present
in the course of the middle meningeal artery and its branches;
and I shall also go back to the origin of the internal maxillary
artery of which the middle meningeal is a branch. I made four
examinations of this artery upon three cadavers and found that
in each case it was given off from the external carotid almost at
a right angle. Examination of the origins of the middle menin-
geal, in the same subjects, showed that in three cases it arose at
a right angle from the internal maxillary, and in one case at an
angle slightly greater.

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Just after the artery passes through the foramen spinosum it turns outward onto the inner surface of the base of the skull at a right angle. The uniform presence of at least a slight curve in the main trunk, except when this is very short, has already been alluded to. This curve was seen to be so marked as to approximate a right angle in eleven cases, being but a little greater than a right angle in six more. Long main trunks may have a second curve.

The anterior branch is often given off at an angle to the main trunk. This in five cases approximated a right angle. The curve constantly present in the anterior branch on the upper part of the great wing of the sphenoid has been mentioned previously. This approximated a right angle twelve times, was S-shaped once, wave-like once, and of less but varying degrees of acuteness in the remainder of the cases. Additional curves occur irregularly higher up in the course of the anterior branch and its divisions or branches.

The posterior branch is given off from the main trunk at a right angle eight times and at an angle of 135 degrees twice; the angle being less acute in other cases; and we have seen that in most cases it describes a more or less sharp curve on the squamous portion of the temporal bone as it lies parallel with the squamo-parietal or squamo-sphenoidal and squamo-parietal suture.

It will thus be seen that beginning with its origin at the external carotid, the blood-supply to the dura mater traverses constantly three angles which are practically right angles, and that in addition to this it passes at least two curves of greater or less acuteness, one in the main trunk and one in the anterior or posterior branch, before being distributed.

The numerous curves in the arteries supplying the pia mater, the vertebral and internal carotid, and through it the brain substance, have long been noted, and have had ascribed to them the *rôle* of diminishing the velocity of the current of blood, but, so far as I know, the equally pronounced and numerous curves in the artery furnishing the chief supply to the dura mater have never before received especial notice.

Distribution of the Middle Meningeal Artery on the Inner Surface of the Parietal Bone.—The inner surface of the parietal bone is supplied to a slightly greater extent by the anterior than by the posterior branch, so that the line of demarcation between the portions of the bone supplied by each of the branches would be drawn between a point slightly back of the middle of the upper or sagittal border of the bone, and a point somewhat behind the middle of the lower border, or at three centimetres anterior to the posterior extremity of the squamo-parietal suture. From this average, however, there are great deviations, so that in some cases the whole upper border and even part of the posterior border is supplied by the anterior branch, while in others the whole lower border may be supplied by the posterior branch.

The only portion never supplied by the anterior branch is a triangular portion, about three centimetres across, at the posterior inferior angle. The only portion never supplied by the posterior branch, is anterior to a line drawn from the anterior inferior angle to a point on the upper border three centimetres from its anterior extremity.

In by far the greater number of cases the point of demarcation on the upper border lies in the middle third, averaging about its middle on the right side and somewhat posterior to the middle on the left. (See Fig. 1.)

Orbital Branch.—An orbital branch of the middle meningeal artery is described by anatomists as constantly present and passing through the sphenoidal fissure, or a small foramen near it, into the orbit to anastomose with a branch of the lachrymal, which is from the internal carotid through the ophthalmic artery. Upon the skulls, however, I found that in a majority of cases there was no groove present of a sufficient size to be recognizable. I found the groove present in thirty-eight cases, nineteen on each side, but not always on both sides of the same skull. In several cases where no groove could be seen, a small canal was seen running into the orbit, indicating the presence of the orbital branch.

In the cases where the groove was seen, it was designated as being small, of moderate size, and large in about an equal

number of cases on both sides. In about one-third of the cases
it originated from the main trunk, in the remainder from the
anterior branch. Its origin was generally upon the upper part
of the great wing of the sphenoid.

Its location is, with but few exceptions, entirely upon the
sphenoid, and its direction forward or forward and upward. I
found that it entered the orbit through the sphenoidal fissure
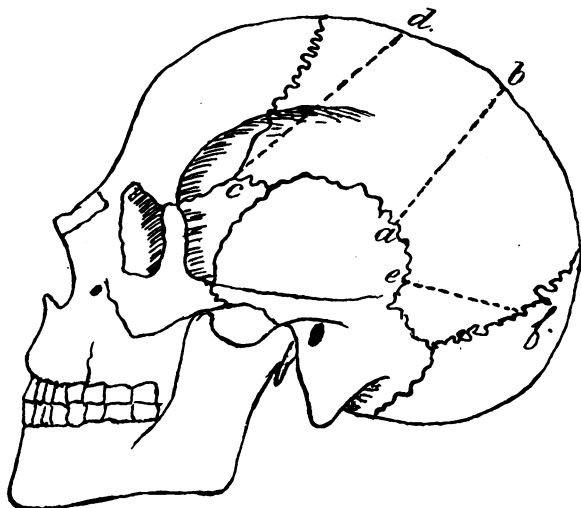seven times, and through a special canal (canalis cranio-orbitalis

FIG. I.—Distribution of the anterior and posterior branches on the
parietal bone; *a, b,* shows the line of demarcation between the portions
supplied by the two branches in an average case; *e, f,* shows the poste-
rior limit of the portion which may be supplied by the anterior branch;
c, d, shows the anterior limit of the portion which may be supplied by
the posterior branch.

of Haller) generally in the great wing of the sphenoid, but some-
times just at the spheno-frontal junction just external to the outer
angle of the sphenoidal fissure, thirty-one times. I would not,
however, assume from these thirty-eight cases that this was the
ratio of the two methods of entering the orbit in all cases, for it
may be that, as a rule, the groove for the artery is more pro-
nounced when it passes through a foramen than when through
the fissure.

In one skull I found the orbital branch upon the left side of such size and course as to make me regard it as taking the place of the anterior branch of the middle meningeal, and as proceeding from the orbit to the cranial cavity. The branch was of large size and passed out of the orbit through the outer angle of the sphenoidal fissure proceeding thence to the anterior inferior angle of the parietal bone, then upward parallel to and one centimetre behind the coronal suture, giving off branches as the anterior branch ordinarily does. In this case the posterior branch was of average size and distribution, entering the skull through the foramen spinosum and giving off one-half centimetre from the foramen spinosum a very small branch analogous to the anterior branch which passed forward and outward on the temporal bone just behind the squamo-sphenoidal suture for 1.5 centimetres and then became lost. A second very small branch given off from the posterior branch 0.6 centimetre farther on crossed the temporal and sphenoid bones and anastomosed with the orbital branch.

Steiner found in six cases the orbital branch from the lachrymal taking the place of the middle meningeal to a greater extent even than in the case which I have just described; for the posterior branch was smaller than normal in his cases, in some very small and in some entirely wanting, as was also the foramen spinosum.

Arteria Temporalis Accessoria.—This is a rare branch, so named by Krause. It is described as arising either from the main trunk or posterior branch and perforating the squamous portion of the temporal bone about two centimetres below its upper border, making its appearance upon the outer surface of the skull.

Gruber found it twenty-five times in 4000 skulls; Krause observed it in 0.8 per cent. of all the cases examined; Steiner found it in two skulls, it being present on both sides of one of them. I found it in two skulls, being present on both sides of each. In one of them it was given off from the main trunk at the foramen spinosum on both sides, in the other it was given off on the right side from the posterior branch 1.5

centimetres from its origin, and on the left from the external petrosal branch. In each case it entered a small canal 0.3 or 0.4 centimetre below the squamo-parietal suture on the inner surface of the skull, and made its exit on the outer surface at the highest point of the squamo-parietal suture, running upward on the parietal bone.

Symmetry of the Two Sides of the Skull in Regard to the Distribution of the Middle Meningeal Artery.—In almost all of the skulls examined a marked tendency to symmetry between the two sides was noticed in regard to the size, location, direction of the various parts of the artery as well as the arrangement and distribution of its branches. There were found, however, so many exceptions to an exactly symmetrical arrangement, as to show that any inferences as to the arrangement on one side of the skull drawn from one's knowledge of the other side would be very likely to be erroneous.

The Presence of Bony Canals in the Course of the Middle Meningeal Artery.—In sixty cases, thirty on the right side and thirty on the left, but not always on both sides of the same skull, there was present in the course of the anterior branch, in the neighborhood of the anterior inferior angle of the parietal bone, a bony canal through which the anterior branch ran. In twenty-three skulls it was found on both sides. Steiner found this bony canal in thirty-eight cases. Its length varies from 0.3 to 2.8 centimetres, being generally between one and two centimetres.

It is always located on the parietal bone, but in two cases its beginning is upon the sphenoid, soon, however, passing onto the parietal. It begins generally at the spheno-parietal suture, most frequently at its anterior extremity, but sometimes it begins on the parietal, in which case it is, with three exceptions, within one centimetre of the spheno-parietal suture. The greatest height above the suture at which it arises is 1.4 centimetres. Its direction is upward and backward, practically parallel with the coronal suture, its exit being within one centimetre of that suture. Occasionally it bifurcates above. Sometimes it has a small foramen or canal opening into it anteriorly for the passage of the ramus fronto-basilaris.

Sites for Trephining for the Middle Meningeal Artery.—In my study of the sites for trephining, my locations refer to the outer surface of the skull.

The first requisite of a method for locating the site for trephining for a branch of the middle meningeal artery is that it should locate that branch with certainty.

The second is that it should expose the branch sought in the most desirable place.

The third is that it should be as simple as possible.

If it be the anterior branch which we are seeking, three factors have a preponderating influence upon the desirability of the site. These three factors are—

(1) The relation of the site to the bony canal, if the latter is present.

(2) Its relation to the orbital branch.

(3) Its relation to the bony ridge running along the lower part of the coronal suture.

If it be the posterior branch that we seek, the proximity of the lateral sinus is the most important factor for consideration. Of course, no method for locating the main trunk can be expected to reach this with any uniformity, for, when present, it is frequently too short to reach.

If the site for trephining the anterior branch be so located as to strike the artery while it lies in a bony canal, the artery would unavoidably be cut through before the button of bone could be removed, causing hæmorrhage during the process of its removal, and necessitating the enlargement of the opening along the course of the artery before the latter could be secured. Probably plugging the canal with antiseptic wax would control hæmorrhage temporarily after removal of the button. If the location were such as to reach the artery below its orbital branch, ligation of the vessel for the purpose of checking hæmorrhage from a rent in the artery higher up would prove unsuccessful owing to the supply of blood which would be brought from the lachrymal artery through the orbital branch. In case the orbital branch were so large as to constitute the source of the anterior branch, a low site might not reach any portion of the vessel,

which would pass above it. The fact that a given site reaches the orbital branch in a case where this is of average size must not lead one to the conclusion that it would reach this branch in a case where it constituted the source of the anterior branch; for, while in the former case, the orbital branch generally extends in a downward and backward direction from the external angle of the sphenoidal fissure, in the latter it generally extends upward and backward. It is seen, then, that it is desirable to reach the anterior branch at or above the location of the orbital branch.

The Bony Ridge.—Extending outward onto the inner surface of the lateral wall of the skull, from the angle of junction of the great wing of the sphenoid with the orbital plate of the frontal, is a bony ridge, whose formation ordinarily is contributed to about equally by the frontal and parietal bones. On the lateral wall of the skull this ridge is located along the lower portion of the coronal suture. If this ridge is of average length, it inclines at its upper part, backward and upward from the coronal suture, being located, consequently, in this portion, on the parietal bone. Occasionally its lower portion is contributed to more largely by the frontal than by the parietal, but the upper portion, unless the ridge is of less than average length, is composed almost always principally of the parietal. In cases where the great wing of the sphenoid extends high on the side of the skull, it may contribute to the formation of the lower end of the ridge, either forming the whole of this end, or sharing its formation with the frontal.

If the anterior branch of the artery runs in a canal, this canal is generally located in this ridge; only in case where the ridge is short the canal may begin above its upper end. When the canal is in the ridge, it enters it at its posterior border. If there is no canal, the anterior branch lies in a groove, either in the ridge, generally in its posterior part, but occasionally as far forward as its summit, or it lies farther back within a short distance of the posterior margin of the ridge. It is only as a rare exception that the anterior branch is found anterior to the ridge, and even in this case it is anterior to the upper extremity only of

the ridge, having arrived at this situation by passing through the ridge from below, in a canal, or, much more rarely, in a groove. I found the artery anterior to the upper extremity of the ridge four times.

This ridge is of some surgical significance. If the trephine opening is so located as to involve the ridge, the button of bone will be more difficult to remove owing to its greater thickness in the portions of its circumference involving the ridge than elsewhere. If the portions of the ridge involved contains the anterior branch in a canal, this will inevitably be lacerated before the button can be removed.

As a surgical landmark the ridge is of value; for, if the anterior branch be not exposed by an opening involving the ridge, we know that we must seek posteriorly for it, the few exceptions having to do with the upper extremity only of the ridge, and being those rare ones where the anterior branch has passed through the ridge from below and posteriorly.

In Krause's osteoplastic flap operation, of which I shall speak later on, the ridge is cut low down at its junction with the fronto-sphenoidal angle, thus leaving the bony canal, if present, upon the flap.

The Anterior Branch.—The methods for locating the anterior branch which I tested upon the skulls were Vogt's, Witherle's, Krönlein's, Kocher's, Steiner's, and the thumb method. In order that my conclusions as to success or failure of a given method might be of a practical nature, I have not made the test as to whether the artery was found at the exact spot reached by the measurements designated in a given method, but as to whether it would come within the circumference of a one-inch trephine applied with its centre at the indicated point. My method of testing this was to apply the centre of a circular piece of adhesive plaster, one inch in diameter, stained black and having a small perforation in its centre, just at the point indicated. In case the skull is translucent, as it usually is in the neighborhood of the anterior branch, it can easily be seen, by holding it to the light, whether this black disk covers the artery or not. I tested the accuracy of this method by control experiments, in which I

located the site upon the inside of the skull by calipers and drew a circle with a half-inch radius around it, and found the two methods to give identical results. In case the skull is not translucent, and this is the rule with the posterior branch, the site had to be located inside, as just mentioned.

Vogt's Method.—Vogt's method locates the anterior branch at the intersection of a horizontal and a vertical line drawn, the former two fingers'-breadth above the zygoma, the latter a thumb's-breadth posterior to the frontal process of the malar bone. This location would vary, of course, with the breadth of fingers and thumbs of the different persons applying it. Two fingers'-breadth with the writer equals 3.5 centimetres, and a thumb's-breadth equals 2.2 centimetres.

A circle one centimetre in diameter with its centre at the posterior extremity of the spheno-parietal suture would include the great majority of the sites. Vogt's method reaches the anterior branch every time, including the case in which it arises from the orbital branch.

In fifty-eight out of the sixty cases in which a bony canal was present it involved the canal. With very few exceptions it reached the ridge every time, this coming within the anterior segment of the trephine, which latter sometimes reached only the posterior portion of the ridge.

This site also exposes the main trunk seven times, it being in these cases at least 3.7 centimetres long; eight times it reaches the first posterior branch of the anterior branch; six times the orbital branch, and twenty-five times the posterior branch.

Three operations upon the cadaver were made by this method. In two cases the anterior branch was found, and in one not found. In the latter its first posterior branch was exposed. In one case where the anterior branch was reached it was in a canal, in the other case not.

Witherle's Method.—Witherle's method consists of two parts, the first locating the anterior branch at the intersection of a vertical line drawn one and a half inches back of the external angular process of the frontal and a horizontal line drawn one inch above the zygoma (I measured from the upper border of the

zygoma), and the second locating it at the intersection of the same vertical line and a horizontal one drawn one and a half inches above the condyloid process of the inferior maxilla.

My tests refer to the first part only of this method, which reached the anterior branch seventy-four times, including the case in which it arises from the orbital branch; failing to reach it twenty-six times. · When not reached, the anterior branch lies anterior to the trephine opening, sometimes barely so, and from this up to a distance of 0.8 centimetre. This method locates the point for the centre of the trephine on the temporal, except in four cases. In twenty-five cases it reached the artery in a bony canal. It generally reaches as far forward as the ridge, which is then at the anterior margin of the trephine opening; but the ridge sometimes escapes anteriorly.

This site also reaches the main trunk twenty-three times; the orbital branch, six times; the first posterior branch of the anterior branch, six times; the posterior branch proper, sixty-three times; and a minor branch twice. In every case where the main trunk was reached the anterior branch was also reached.

In three experiments on the cadaver the anterior branch was found each time. In one the posterior branch also.

Krönlein's Method.[1]—Krönlein's method locates the site for trephining three to four centimetres back of the external angular process of the frontal bone on a line drawn from the supra-orbital border parallel with the " base-line," which is a line from the lower border of the orbit to the centre of the external auditory meatus. In making my tests of this method I used the distance of three centimetres back of the external angular process.

By this method the anterior branch was reached ninety-nine times, including the case where it arises from the orbital branch, escaping in one case just postero-inferiorly. By this method the centre of the trephine is located on the sphenoid in a great majority of cases.

The artery was reached in a bony canal forty-six times. In the remaining cases where a canal is present the site is located beneath it. The ridge was found in the majority of cases to lie

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[1] Loc. cit.

across the middle of the trephine site, or just anterior to the middle.

This site also reaches the main trunk twenty times; the orbital branch, sixteen times; the first posterior branch of the anterior branch, seven times; and the posterior branch, thirty-three times.

In one experiment on the cadaver upon the right side the anterior branch was found.

Kocher's Method.—Kocher's method locates the trephine opening immediately above the middle of the zygoma. As he
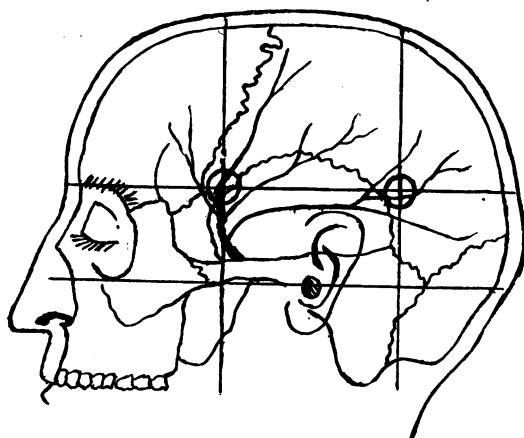

FIG. 2.—Lines used by Krönlein to locate the main branches of the middle meningeal artery. (After Krönlein.)

does not mention the points between which he measures to reach the middle of the upper border of the zygoma, I have made use of the junction of the upper border of the zygomatic process of the malar with the posterior border of the frontal process of the same bone for the anterior point, and the portion of the posterior root of the zygomatic process of the temporal, which is palpable in the living person just in front of the pinna, as the posterior point.

By this method the anterior branch was reached sixty-one times. In the thirty-nine cases in which the anterior branch escaped, the main trunk was reached fourteen times. As it

answers the same purpose, so far as the anterior branch is con-
cerned, to reach either the anterior branch itself or the main
trunk, we might add these fourteen cases to the sixty-one and
say that, for practical purposes, the anterior branch was reached
seventy-five times. Among the twenty-five cases where it es-
capes absolutely was the one in which it arose from the orbital
branch, being one-half centimetre anterior. When the anterior
branch is not reached, it lies either anteriorly or antero-superiorly
to the trephine opening, being within one-half centimetre of its
anterior margin, except in two cases where it is respectively 0.8
and one centimetre anterior.

By this method the centre of the trephine is located upon
the squamous portion of the temporal bone, generally between
one and two centimetres from the squamo-sphenoidal suture, but
sometimes closer to it.

In no case does it reach the anterior branch in a bony canal.

The anterior margin of the opening is between 0.6 and two
centimetres posterior to the spheno-frontal angle (or lower end of
the ridge). As in all but two of the cases where the anterior
branch escapes, it lies within one-half centimetre anteriorly to the
trephine opening, and as there is room in every case to move
this opening one-half centimetre anteriorly without involving the
spheno-frontal angle, I would suggest that this method would
be more efficient, if changed so that the location would be imme-
diately above a point one-half centimetre anterior to the middle
of the upper border of the zygoma. Possibly this would lessen
the number of cases in which the posterior branch is reached,
and Kocher intended this method to reach the posterior branch
as well as the anterior, he using Vogt's method to locate the
anterior branch alone.

This method reaches the posterior branch sixty-six times,
and in five of the cases where it fails to reach it, it reaches the
main trunk, so that, speaking practically, we might say that the
posterior branch was reached seventy-one times.

The main trunk is reached in forty-eight cases, the orbital
branch in eight, the first posterior branch of the anterior branch
in seven, and the posterior branch in sixty-six, as already stated.

In five operations upon the cadaver by Kocher's method, four on the right side and one on the left, the anterior branch was found in all but one case on the left side, where it lay 0.4 centimetre anterior. The main trunk was reached three times and the posterior branch four times.

Steiner's Method.—Steiner locates the site for the anterior branch as follows : Draw a line from the middle of the glabella

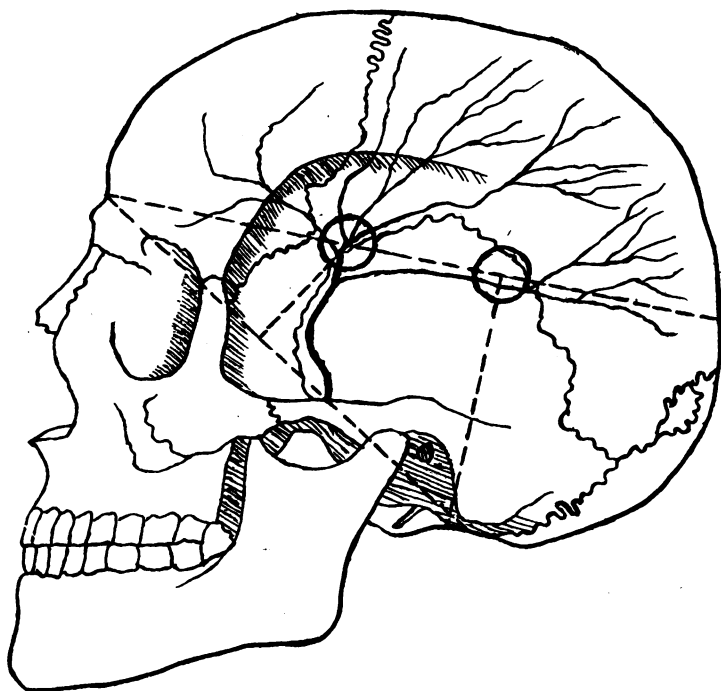
FIG. 3.—Lines used by Steiner to locate the main branches of the middle meningeal artery. (After Steiner.)

to the tip of the mastoid process, and ereƈt upon the middle of this line a perpendicular; where this perpendicular intersects a line passing through the middle of the glabella and extending horizontally around the head, there place the trephine.

By this method the anterior branch is reached ninety-eight times, including the one arising from the orbital branch, passing closely behind the trephine opening in the other two.

It involves the bony canal fifty-six times, being above it in two cases and below it in one. It nearly always involves the ridge, often its thickest part, but occasionally only its insignificant upper extremity. Rarely it lies above the ridge entirely.

It reaches the main trunk three times, none of these three being in the same cases as where the anterior branch failed to be reached. It reaches the orbital branch three times, and the posterior branch ten times.

In four operations upon the cadaver, two on each side, the artery was reached three times, lying 0.2 centimetre posterior to the trephine opening in one case. Of the three cases reached, in two the canal was involved.

Thumb Method.—One of the earlier methods of locating the site for the anterior branch is what I have designated the thumb method, which places the site at the intersection of a vertical and horizontal line, the former drawn the length of the distal phalanx of the thumb back of the external angular process of the frontal bone, the latter drawn the same distance above the upper border of zygoma. The locations, of course, will vary according to the differences in length of the phalanx in the different persons using the method. The writer's distal phalanx measured 3.7 centimetres, or one and a half inches.

By this method the anterior branch was reached in ninety-seven cases, including the case where it arises from the orbital branch. In the three cases where it escaped, it lay closely anteriorly. In none of these three cases was the main trunk reached.

In fifty-five cases the anterior branch was reached while in a bony canal. In nearly every case the ridge was involved, but sometimes only its insignificant upper extremity, while sometimes, though rarely, it escapes anteriorly or inferiorly.

It reaches also the main trunk six times, the orbital branch twice, the first posterior branch of the anterior branch twice, the posterior branch twenty-seven times, and its ascending branch once.

In two operations made on the cadaver the anterior branch was found both times.

TABLE SHOWING COMPARISON OF RESULTS OF THE TESTS OF THE
METHODS FOR LOCATING THE TREPHINE SITE FOR THE
ANTERIOR BRANCH.

Methods.	Anterior Branch reached.	Main Trunk reached in how many Cases where Anterior Branch escapes.	Total.	Anterior Branch reached in Bony Canal.	Ridge Involved.	When Anterior Branch arises from the Orbital Branch. Reached or not.	Reaches Posterior Branch.
Vogt's	100	. .	100	58	Generally in anterior segment of trephine opening.	Yes.	25
Witherle's . . .	74	. .	74	25	Generally at anterior margin.	Yes.	63
Krönlein's . . .	99	. .	99	46	Generally at middle.	Yes.	33
Kocher's . . .	61	14	75	. .	No.	No.	66
Steiner's	98	. .	98	56	Generally.	Yes.	10
Thumb	97	. .	97	55	Generally.	Yes.	27

Comparison of Methods for reaching the Anterior Branch.—
In comparing the results of the tests of the different methods of
locating the site for trephining for the anterior branch, we see
that in regard to certainty of reaching the artery, Vogt's method
leads with 100 per cent. of successes, while Krönlein's, Steiner's,
and the thumb method yield but slightly less perfect results.
Witherle's and Kocher's methods falling far below. In regard
to simplicity, Steiner's method is the most complicated, there
being but little choice between the other methods.

In regard to desirability, Vogt's, Steiner's, and the thumb
method involve the bony canal and the ridge with practically the
same frequency, and each one reaches the anterior branch in the
single case in which it originated from the orbital branch, leaving
little choice between them. Krönlein's involves the bony canal
less frequently, Witherle's still less frequently, and Kocher's not
at all, the latter being the only method in which the ridge is not
involved as a rule, and the only one not reaching the anterior
branch from the orbital. The posterior branch is reached most
frequently by Kocher's and Witherle's, while of the remaining

methods Krönlein's leads in this respect. Vogt's and the thumb method have the disadvantage of being variable according to the size of the fingers and thumbs of persons applying them. The one case where the anterior branch arises from the orbital branch affords an insufficient test as to whether the artery thus arising would be found by the various methods in a series of cases, but I would expect that Kocher's method would always fail to reach it, that Witherle's generally would, while the other methods would probably reach it in most instances.

Taken all in all, I think we must select Krönlein's method as the most advantageous. It is not variable, is practically certain to reach the artery, involves the bony canal less often than the other methods approaching it in accuracy, is just as likely as any to reach an anterior branch derived from an orbital branch, and reaches the posterior branch oftener than other methods equally accurate.

Other Possible Methods for locating the Anterior Branch.— Before leaving the subject of the anterior branch, I would call attention to the fact that I have shown that in every case the anterior branch crosses, or lies upon the spheno-parietal suture; that the suture is from one to 1.5 centimetres long, and consequently the anterior branch must be in every case within 1.5 centimetres of the internal aspect of the lower extremity of the coronal suture. As the external aspect of this suture is from one-half to one centimetre anterior to the internal, owing to the overlapping of the parietal bone, the anterior branch will lie farther from the lower end of the coronal suture on the external aspect of the skull, but the most posteriorly located anterior branch will be but 2.5 centimetres (one inch) back of the coronal suture as seen on the outer surface of the skull. It follows, then, that every anterior branch would fall within the circumference of a one-inch (2.5 centimetres) trephine applied with its centre on a level with the lower end of the coronal suture and its anterior margin immediately back of this point.

Unfortunately, this fact is principally of theoretical value, for the sutures are often hard to identify, even when seen, and the lower end of the coronal suture is frequently found obliterated.

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Even if used, this method would probably be in no way superior to Krönlein's, and no method can be considered practical which does not measure from palpable points upon the skull.

Again, we saw that the anterior branch crossed a horizontal line drawn backward from the lower extremity of the external angular process of the frontal bone between 1.7 and 3.7 centimetres posterior to that process. Here, again, we have at hand a method for locating the anterior branch, for a one-inch (2.5 centimetres) trephine applied with its centre 2.7 centimetres back of the process would reach the artery in every case and leave a little room to spare both anteriorly and posteriorly. But here again arises the difficulty of locating our bony point, for the external angular process of the frontal is smoothly continuous with the frontal process of the malar bone, and cannot be distinguished through the skin. Eight-tenths to 1.5 centimetres downward and backward from the lower end of the external angular process of the frontal is the prominent angle on the posterior border of the frontal process of the malar bone. The position of the external angular process might be located from this, but this would lessen the simplicity of the method, which, at any rate, would be practically identical with Krönlein's. Consequently, I refrain from adding these two to the already too great number of methods for locating the anterior branch.

The Posterior Branch.—The methods for locating the posterior branch which I tested upon the skulls were Krönlein's and Steiner's.

Krönlein's Method.—Krönlein's method for locating the posterior branch places the site for trephining at the intersection of a line drawn from the supra-orbital border parallel with the "base-line," previously mentioned, and a line drawn vertically from the posterior border of the mastoid process. The horizontal line is the same as that on which Krönlein locates the anterior branch.

By this method the posterior branch is found in forty-one cases. The location of the site is on the parietal bone within 2.5 centimetres of the squamo-parietal suture ninety times, on the squamo-parietal suture within 2.7 centimetres of its

posterior extremity eight times, and on the squamous portion of the temporal within 0.8 centimetre of the squamo-parietal suture twice.

In the fifty-nine cases in which the posterior branch escapes, both its divisions are exposed in nine. As this is equivalent to reaching the posterior branch itself, we may say that the method reaches that branch in 50 per cent. of all cases. In the fifty cases in which neither the posterior branch nor both of its divisions is reached, the inferior division is reached in twenty-five, the superior division in four, and a minor branch in nine. In seven cases the accessory posterior branch of the main trunk is found.

In twenty-six cases the lower margin of the trephine opening overlaps the groove for the lateral sinus. In the remaining seventy-four cases the margin of the trephine opening comes within one centimetre of the lateral sinus in forty-six cases and within one-half centimetre of it in twenty-one of these. As the sinus, when distended with blood, extends beyond the limits of the groove on the bone, these latter locations are dangerously near it.

Steiner's Method.—Steiner's method for locating the posterior branch places the site at the intersection of a line passing through the middle of the glabella and extending horizontally around the head,—that is, the same line on which the anterior branch is located, and a line drawn vertically immediately in front of the mastoid process, turning forward the pinna in order to draw it.

By this method the posterior branch is found in thirty-six cases. The location of the trephine site is on the squamo-parietal suture, three times, or within two centimetres of it, generally within one centimetre of it, on the parietal bone thirty-one times and on the temporal forty-six times.

In five of the sixty-four cases in which the posterior branch was not found both its divisions were reached, and as this is equivalent to securing the posterior branch itself, we may say for practical purposes that this method reaches the posterior branch forty-one times. In the fifty-nine cases in which neither

the posterior branch nor both of its divisions were reached, the superior division is reached nine times, the inferior four times, and a minor branch ten times, while the accessory posterior branch of the main trunk was reached twice, a branch of the anterior branch, either its posterior division or its first or second posterior branch fifteen times, and the anterior branch itself three times

In no case is the groove for the lateral sinus involved, but in one case the edge of the trephine opening just reached to the margin of this groove. In two more cases it reached within a half centimetre of it, and in two more within one centimetre of it.

In three operations on the cadaver by this method the posterior branch was found once.

Comparison of Methods for reaching the Posterior Branch.— The methods for locating the posterior branch are much less satisfactory in their results than those for the anterior, reaching this branch even less frequently than it is reached by Kocher's or Witherle's methods, which are designed for reaching the anterior branch, the latter being intended exclusively for the anterior. The two methods locate the site on the parietal bone in 90 and 31 per cent. of cases respectively, and as we have seen that the posterior branch divides on the temporal bone and squamo-parietal suture twenty-eight times, we see at once the necessity of failure in a considerable number of cases.

I do not believe that any method can be devised which will not fail to reach the posterior branch in a large percentage of cases, owing to the great differences in its course; but a site lower down, nearer its origin, will reach the posterior branch more frequently than either of the methods given.

In regard to the two methods I have tested, the choice must fall upon Steiner's, although it does not reach the artery as frequently as Krönlein's, the fact that the latter involves the lateral sinus in a considerable percentage of cases positively contra-indicating its employment.

TABLE SHOWING COMPARISON OF THE RESULTS OF THE TESTS
OF THE METHODS FOR LOCATING THE TREPHINE
SITE FOR THE POSTERIOR BRANCH.

Method.	Posterior Branch reached.	Both Divisions reached.	Total.	Involves Lateral Sinus.
Krönlein's	41	9	50	26
Steiner's	36	5	41	0

Hartley-Krause Osteoplastic Flap.—There remains yet to be mentioned another method of reaching the various portions of the middle meningeal artery,— namely, the turning down of an osteoplastic flap in the same manner that Hartley and Krause devised for reaching and removing the Gasserian ganglion.

I did not make any tests of this method upon the dry skulls, but I have performed the operation nine times upon the cadaver, using Krause's flap. In every case the main trunk and anterior and posterior branches were accessible, and in four the orbital branches were also found. In six cases the artery ran in a canal and was unavoidably ruptured in turning down the flap. This is not a serious matter, as immediately after the rupture the whole field is so exposed that the end of the ruptured vessel can be caught at once. The artery in every case remained adherent to the dura mater, pulling out of the canal in the bone. In one case where the canal extended higher than usual it was cut off in the upper transverse portion of the bone incision, and in two cases the artery was very close behind the anterior portion of the bone incision.

Krause's description of the flap is as follows: " The pedicle of the flap lies above the zygoma. The incision extends from just in front of the tragus upward, bowing out convexly backward and then describing a semicircular bow forward in such a manner as to be convex also anteriorly, and ending at the malar bone, so that the base of this uterus-shaped flap is 3.3 centimetres, its height 6.5 centimetres, and its greatest breadth above 5.3 centimetres."

Hartley[1] describes his incision as omega-shaped, having its base at the zygoma, and measuring a distance marked by a line drawn from the external angular process of the frontal to the tragus. The curved and rounded portion of the incision reached as high as the supratemporal ridge; the whole flap approximating in size a circle three inches in diameter.

I regard the osteoplastic flap as the ideal method of reaching the middle meningeal artery, for by it the removal of the clot, which is generally present when this operation is done, is facilitated, and the artery can be ligated in the most desirable location even down to the foramen spinosum, if necessary, as all the important portions of it and its communicating branches are freely exposed. So important does Steiner regard this method as to state that we now have no use for the more-defined locations of other methods except where some contra-indication to the formation of a flap is present. These contra-indications he named as the presence of a compound fracture, or great injury to the soft parts, each of which would threaten the nutrition of the bone-flap. If, however, this method should be adopted by surgeons, I doubt whether these contra-indications would always have to be considered as absolute, for such large areas of bone, which has been entirely detached, have been implanted with success, that doubtless this bone-flap would grow in spite of considerable injury to the adjacent soft parts.

Relations of Middle Meningeal Artery to the Trephine Site used in Rose's Operation for reaching the Gasserian Ganglion.— In Rose's operation for removal of the Gasserian ganglion a trephine opening is made in the great wing of the sphenoid a little anterior and external to the foramen ovale, the edge of the trephine just impinging on the edge of the foramen. I tested the frequency with which the middle meningeal artery would be involved in this operation, using a two-centimetre trephine as recommended by Professor Edmund Andrews. I found that the main trunk was involved twenty-six times and the anterior branch twelve times, showing the necessity of securing extracranially

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[1] Intracranial Neurectomy of the Fifth Nerve, ANNALS OF SURGERY, 1893, XVII, 511–526.

either the middle meningeal, or else the internal maxillary in such a way as to control the middle meningeal. It must be remembered that the middle meningeal is the first branch of the internal maxillary and lies well back, so that, although the ligation of the internal maxillary is a routine proceeding in the operation, it might be ligated anteriorly to the origin of the middle meningeal, unless the latter is borne in mind.

CONCLUSIONS.

From the results of my researches, I think we are justified in drawing the following conclusions:

(1) That the course and distribution of the middle meningeal artery are subject to wide variations.

(2) That after the artery leaves the foramen spinosum there is no location at which a portion of the main trunk or one of its terminal branches has a constant and defined position, except where the anterior branch crosses the spheno-parietal suture on to the anterior inferior angle of the parietal bone.

(3) That a trephine opening one inch in diameter made immediately back of any portion of the coronal suture will almost invariably reach the anterior branch or a branch from it.

(4) That in a great majority of cases there is a main trunk of the artery within the cranium.

(5) That the anterior branch may be derived from the orbital branch of the lachrymal branch of the ophthalmic.

(6) That the parietal bone is supplied to slightly greater extent by the anterior than by the posterior branch.

(7) That the blood-supply to the dura mater traverses as many and as pronounced curves as that to the pia mater.

(8) That while there is a tendency to symmetrical arrangement on the two sides of a given skull, the exceptions to this are so numerous that we can make no practical use of this symmetry.

(9) That in a majority of cases the anterior branch is inclosed in a canal at the anterior inferior angle of the parietal bone.

(10) That, in locating the anterior branch, that site is

most advantageous which reaches it high enough to prevent its escaping in case it originates from the orbital branch, and to expose or lie above the orbital branch when it exists merely as a communicating branch ; and which involves the bony canal and the ridge along the lower end of the coronal suture least frequently.

(11) That for locating the anterior branch, Krönlein's method is the most advantageous.

(12) That no method will locate the posterior branch with much certainty.

(13) That in locating the posterior branch one must carefully avoid the region of the lateral sinus.

(14) That Steiner's method is the most advantageous for locating the posterior branch.

(15) That we have in the Hartley-Krause osteoplastic flap the only method fulfilling all the requirements for an ideal exposure of the middle meningeal and its branches.

(16) That shutting off the circulation of the middle meningeal extracranially is an essential step in the performance of Rose's operation for the removal of the Gasserian ganglion.